No Drill Dentistry: Improved Composites and In Vivo Studies

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Currently, limited options exist for treating dental emergencies during space flight. The longer the mission duration, the greater the probability of spontaneous dental problems occurring. The pain and discomfort arising from lost fillings, broken or cracked teeth, and infections can affect mission success. The standard treatment for caries (tooth decay) requires the use of a local anesthetic, drilling to remove the decayed areas of a tooth, and tooth reconstruction. Such procedures are not practical for space flight and future exploration. To address these issues and optimize crew health, innovative technology is under development to enable emergency caries treatment and tooth repair to be performed in flight by astronauts who are not experts in dentistry.

The Biomedical Engineering Technology Development Team at Johnson Space Center previously developed a lightweight handheld microwave system consisting of a sharply focused antenna, signal source, and power amplifier for dental applications. Using unique test beds, the team demonstrated that microwave energy could effectively eradicate the caries-causing bacteria—Streptococcus mutans. To further advance this innovative technology for future human application, small-animal studies were performed. The objective was to determine the effects of microwave energy on rat incisors and the immediate surrounding tissues. Incisors were treated with microwave energy for 0, 30, or 60 seconds, and were compared to untreated incisors after different time intervals. Microscopic evaluation, performed by an independent veterinary histopathology expert, focused on gingival tissues, dental pulp, and alveolar bone housing of incisors. Under the conditions of this study, no microwave-associated harmful effects were detected involving incisors, pulpal tissue, gums or bone exposed for 30 or 60 seconds at 1, 7, or 56 days following treatment in this rodent model. These results demonstrate the feasibility of using microwave energy for dental treatments.

In parallel studies, the microwave system was evaluated for its effectiveness in curing new, proprietary composite materials for tooth reconstruction and repair. These tests involved exposing the materials to various curing protocols. Researchers performed a series of crush tests to assess the hardness and quality of the cured composite materials. These tests included composite samples that were: exposed to microwave energy (no pre-curing); pre-cured using microwave energy; or pre-cured with a commonly used dental blue-light instrument. Researchers obtained significantly improved composite results when pre- and post-hardening was performed using microwave energy; i.e., composites were harder and more durable. Future studies are planned to test the in vivo performance of these composites in rodents.

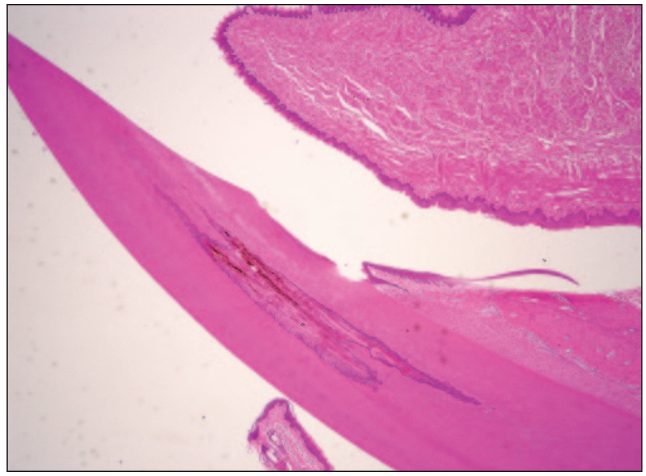

Fig. 1. *Cross section of lower rat incisor stained with H&E showing no damage from radio frequency exposure.*

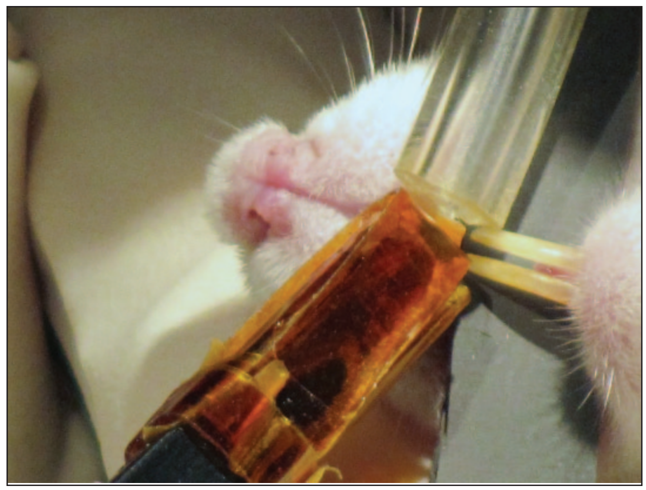

Fig. 2. *Rat incisor being exposed to radio frequency energy.*

Upon completion of additional animal-based studies, further development of this technology will ultimately involve human clinical trials before it can become available for common use. This new technology will revolutionize current dental practices by making it less expensive, simpler, faster, and less invasive with more durable, longer-lasting tooth repairs.